International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 05 | May 2026 www.irjet.net p-ISSN: 2395-0072

Ocean-based Carbon Capture Ships (OCCS)

A.BASKAR[1], A.MURUGAN[2], G.PETER PACKIARAJ[3], C.INDRAKUMAR[4]

[1]Final *Year B.E Marine, PSNCET, Tirunelveli, Tamil Nadu, India*
[2]*Professor, Dept Of Marine Engineering PSNCET, Tirunelveli, Tamil Nadu, India*
[3,4]*Assistant Professsor, Dept Of Marine Engineering PSNCET, Tirunelveli, Tamil Nadu, India*

ABSTRACT-*Ocean-based carbon capture ships (OCCS) present a promising solution to reduce atmospheric CO2 levels by taking advantage of oceanic processes. These specialized vessels capture CO2 from the atmosphere, convert it into a form that can be safely stored in ocean water, and actively contribute to mitigating global warming. This report examines the technical principles, operational aspects, potential impact, and challenges associated with OCCS.*

Keywords: Ocean-Based Carbon Capture (OCCS), Direct Air Capture (DAC),Carbon Sequestration, Marine Technology, Renewable Energy,CO_2 Dissolution, Bicarbonate Conversion, Climate Mitigation, Oceanic Carbon Sink, Sustainable Engineering.

1. INTRODUCTION

Climate change has intensified the need for innovative carbon capture and sequestration (CCS) methods. While terrestrial CCS systems are growing, ocean-based approaches offer substantial potential. Oceans naturally absorb approximately 25% of global CO2 emissions, making them an important carbon sink. The OCCS model is based on this principle, aiming to increase oceanic carbon absorption while minimizing adverse ecological impacts.

1.1 Carbon capture technology

OCCS systems typically use direct air capture (DAC) technology to extract CO_2 from the air. These DAC units use a chemical solvent to bind CO_2, which is then isolated and compressed for separation or transformation. Recent advances in DAC technology have improved the energy efficiency of capture processes, making OCCS more viable.

1.2 Separation methods

Once captured, CO_2 undergoes one of several separation methods:

Direct dissolution: CO_2 is dissolved in seawater in a controlled environment to prevent ocean acidification. This process mimics natural CO_2 absorption but at an accelerated rate.

Bicarbonate conversion: By reacting CO_2 with alkaline substances, OCCS convert CO_2 into stable bicarbonate ions that can be safely dissolved in seawater.

Solidification: In some proposed models, CO_2 is mineralized into solid carbonates, which are stored in deep-sea locations.

1.3 Energy and resource requirements

OCCS are typically powered by renewable energy sources, such as onboard solar panels or wind turbines, to reduce the carbon footprint of the capture process. Additionally, the ships propulsion and energy storage systems are optimized for efficiency to allow extended operations in remote ocean regions.

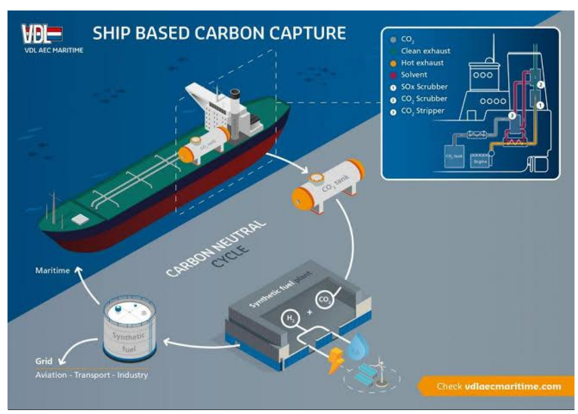

Fig 1- Ship based carbon capture by carbon neutral cycle

2. OPERATION AND DEPLOYMENT

2.1 Deployment Strategy

OCCS ships are deployed to strategic ocean regions where conditions are conducive to effective CO_2 dissolution, such as areas with strong currents that help distribute captured carbon. Seasonal deployments in colder waters can also enhance CO_2 absorption due to the effect of temperature on gas solubility.

2.2 Data and Monitoring Systems

Advanced monitoring systems are installed on OCCS ships to track CO_2 levels, ocean pH, temperature, and ecological impacts. The data collected is critical to refining dissolution processes and mitigating unintended consequences such as local acidification or impacts on marine biodiversity.

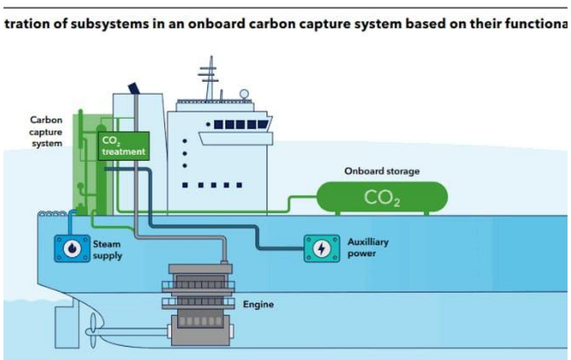

Fig 2 – Subsystem for carbon capturing system in ship

3. ENVIRONMENTAL AND SOCIETAL IMPACTS

3.1 Potential benefits

Increased carbon sequestration: By capturing CO2 in the ocean, OCCS can significantly reduce atmospheric CO2 concentrations and mitigate climate change.

Support for marine ecosystems: Some forms of bicarbonate produced by OCCS can reduce ocean acidity, potentially benefiting ecosystems threatened by acidification.

3.2 Ecological concerns

Acidification risks: Improperly managed CO2 dissolution can lead to local acidification, which can negatively impact marine life.

Disruption of marine habitats: OCCS operations can disturb ecosystems, especially in biologically sensitive areas.

4. TECHNOLOGY OVERVIEW

4.1 Carbon Capture Process

OCCS leverages a process in which seawater absorbs atmospheric CO_2, and then captures the CO_2 through a special on-board extraction mechanism. The captured CO_2 can then be safely stored, reused, or processed.

4.2 Ship design and equipment

1. CO_2 capture chambers: These chambers use chemically engineered filters and absorbers to capture CO_2 dissolved in seawater.

2. Processing units: The ship is equipped with CO_2 extraction and concentration units, which prepare the CO_2 for storage or disposal.

3. Energy systems: Renewable energy sources, such as solar panels and potentially wave-powered generators, would power the carbon capture systems to reduce the carbon footprint of the OCCS.

5. CHALLENGES AND FUTURE DIRECTIONS

5.1 Technical limitations

Current DAC technologies are energy-intensive, making the process expensive. Increasing efficiency and developing cost-effective capture materials are essential for OCCS viability.

2. Policy and regulatory barriers

Ocean-based carbon capture activities fall under marine regulations that vary internationally. Coordinated international guidelines and rigorous environmental assessments are needed to ensure that OCCS deployment is safe and effective.

3. Future research

Research priorities include improving DAC efficiency, assessing long-term impacts on marine ecosystems, and exploring synergies with marine conservation initiatives.

6. EXECUTIVE SUMMARY

The Ocean-Based Carbon Capture Ship (OCCS) project aims to develop a specialized vessel capable of capturing atmospheric CO2 using seawater as the medium. This project will address the global challenge of climate change by leveraging ocean-based technology to remove carbon dioxide, thereby reducing greenhouse gas levels in the atmosphere. The OCCS project combines innovative carbon capture technology with marine engineering to create a scalable, ocean-based solution for removing atmospheric CO2.

7. PROJECT OBJECTIVES

1. Design and Development: Create a prototype vessel equipped with advanced ocean-based carbon capture technology.

2. CO2 Absorption Mechanism: Develop and test systems to use seawater as the medium for CO2 capture.

3. Efficiency Optimization: Maximize CO2 capture efficiency per voyage while minimizing energy consumption and operating costs.

4. Environmental protection: Ensure that the ecological footprint of OCCS is minimal, with measures taken to prevent harm to marine life and ecosystems.

5. Scalability analysis: Conduct feasibility studies on scaling up OCCS technology for large-scale deployment in international waters.

Background and Rationale

The increase in atmospheric CO_2 levels is one of the major drivers of climate change. Traditional land-based carbon capture solutions have limitations in scalability and geographic reach. Oceans, which cover more than 70% of the Earth's surface, play a vital role in natural carbon sequestration processes. By integrating carbon capture technology into ships, the OCCS project seeks to efficiently capture CO_2 at sea, providing an innovative complement to existing land-based solutions

The concept: A large, floating ship specifically designed to capture carbon dioxide (CO_2) from the ocean surface. Since oceans absorb a significant amount of atmospheric CO_2, this ship would filter and capture CO_2 directly from seawater, reducing greenhouse gases and combating climate change.

How it works: The ship would use special membranes or electrochemical cells to extract CO_2 from seawater. Once captured, CO_2 could either be stored in onboard tanks for transport to secure storage facilities or converted into usable byproducts such as synthetic fuels or carbonates that could be sold or used for building materials.

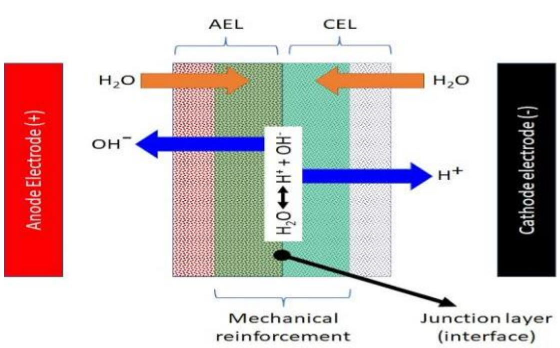

Figure 3-AEL-CEL Junction layer

Features:

1. Direct ocean capture technology: Electrochemical or chemical processes to separate CO_2 from seawater.
2. Modular Design: Interchangeable systems allow the ship to adjust to different ocean CO_2 levels or technological advancements.
3. Renewable Energy Sources: The ship will be powered by onboard solar panels, wind turbines, and even ocean thermal energy.
4. Real-time Ocean Monitoring: Equipped with sensors and AI to monitor ocean health and CO2 levels, helping scientists track environmental changes.
5. Indirectly reduce atmospheric CO2 by reducing the oceans CO2 content.
6. Support environmental restoration and help mitigate climate change by reducing ocean acidification, which benefits marine ecosystems.
7. Act as mobile research laboratories to monitor ocean health and carbon absorption capabilities.

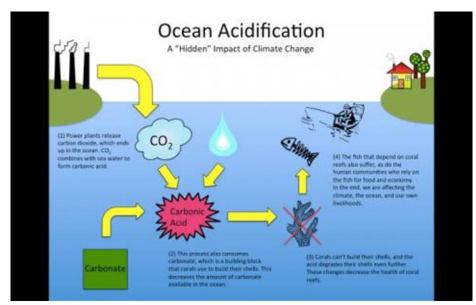

Figure 4-Acidification in the ocean by several impacts

8. This ocean-based carbon capture ship will not only be a game-changing technology for carbon capture but will also promote ocean health and contribute to the Sustainable Development Goals.

8. REFERENCES

1. Sabine, C. L., et al. (2004). The Oceanic Sink for Anthropogenic CO_2. Science, 305(5682), 367-371.

2. Intergovernmental Panel on Climate Change (IPCC). (2021). Sixth Assessment Report: The Physical Science Basis.

3. International Energy Agency (IEA). (2022). Carbon Capture, Utilization, and Storage: A Key Tool for Tackling Climate Change.

4. Centre for Climate Repair at Cambridge. (2023). Ocean-Based Approaches to Carbon Dioxide Removal.

5. Gattuso, J. P., & Hansson, L. (2011). Ocean Acidification. Oxford University Press.

BIOGRAPHIES:

I am pursuing B.E final year Marine Engineering cadet at PSNCET, Tirunelveli, Tamil Nadu.

Working as a Professor, Department of Marine Engineering,PSNCET, Tamil Nadu, India

Working as a Assistant Professor, Department of Marine Engineering,PSNCET, Tamil Nadu,

Working as a Assistant Professor, Department of Marine Engineering,PSNCET, Tamil Nadu, India